WHAT IS CLAIMED IS:

1. A method of inspecting the surface of articles for defects, comprising:

placing the article to be inspected on a table;

in a first phase, optically examining the complete surface of the article on the table inspected at a relatively high speed and with a relatively low spatial resolution;

electrically outputting information indicating suspected locations on the article having a high probability of a defect;

storing said outputted information in a storage device;

and in a second phase, while the article is still on said table, optically examining with a relatively high spatial resolution only said suspected locations stored in said storage device for the presence or absence of a defect in said suspected locations.

2. The method according to Claim 1, wherein said first examining phase is effected by optically scanning the complete article surface to be inspected; and said second examining phase is automatically effected immediately after the first phase by imaging only said suspected locations on a converter which converts the images to electrical signals and then analyzes said electrical signals.

3. The method according to Claim 1, wherein said surface of the article includes a pattern to be inspected; and said first examining phase is effected by making a comparison between the inspected pattern and another pattern serving as a reference pattern, and identifying locations on the inspected pattern wherein the comparison shows sufficient differences with respect to the reference pattern to indicate a high probability of a defect in the inspected pattern.

4. The method according to Claim 3, wherein said second examining phase is also effected by making a comparison between the inspected pattern and the reference pattern, and identifying locations on the inspected pattern wherein the comparison shows sufficient differences with respect to the reference pattern to indicate the presence of a defect at the suspected location of the reference pattern.

5. The method according to Claim 3, wherein said article to be inspected has a plurality of repetitive pattern units, one of which units serves as the inspected pattern and is compared with at least one other unit of said article serving as the reference pattern.

6. The method according to Claim 5, wherein the article to be inspected is a semiconductor wafer having a plurality of like

integrated-circuit dies each formed with like patterns, the pattern of one of which dies serves as the inspected pattern and is compared with the like pattern of at least one other die serving as the reference pattern.

7. The method according to Claim 5, wherein the article to be inspected is a semiconductor wafer having a plurality of like integrated-circuit dies, each die being formed with a plurality of like patterns, one of which patterns of one die serves as the inspected pattern and is compared with another like pattern of the same die serving as the reference pattern.

8. The method according to Claim 5, wherein said first examining phase is effected by the following operations:

generating a first flow of N streams of data representing the pixels of different images of the inspected pattern unit;

generating a second flow of N streams of data representing the pixels of different images of the reference pattern unit;

and comparing the data of said first flow with the data of the second flow to provide an indication of the suspected locations of the inspected pattern unit having a high probability of a defect.

9. The method according to Claim 8, wherein said comparing operation is effected by:

correcting any misalignment between the two flows of data;

comparing the data of each stream of the first flow with the data of the corresponding stream of the second flow to provide an alarm value indicating the significance of the presence of a suspected location in the stream;

and detecting a defect at a pixel location according to N alarm values corresponding to the N streams of data.

10. The method according to Claim 5, wherein said first examining phase is effected by a laser beam which is deflected to scan a line along one orthogonal axis, while the article to be inspected is physically displaced along a second orthogonal axis.

11. The method according to Claim 5, wherein said second examining phase is effected by the following operations:

imaging on a converter each suspected location of the inspected pattern unit and the corresponding location of the reference pattern unit to output two sets of electric signals corresponding to the pixels of the inspected pattern unit and the reference pattern unit, respectively;

and comparing the pixels of the inspected pattern unit with the corresponding pixels of the reference pattern unit to indicate a defect

whenever a mismatch of a predetermined magnitude is found to exist at the respective location.

12. The method according to Claim 11, wherein said imaging operation is effected by imaging each suspected location of the inspected pattern unit and the reference pattern unit at a plurality of different depths, and shifting the electric signals of one set with respect to those of the other set to match the respective depths of the images.

13. The method according to Claim 12, wherein said imaging at a plurality of different depths is effected by moving the inspected pattern unit and reference pattern unit towards and away from the converter.

14. The method according to Claim 13, wherein during said imaging at a plurality of different depths, a lamp is flashed at periodic intervals while the inspected pattern unit and reference pattern unit are being moved vertically with respect to the converter.

15. The method according to Claim 11, wherein said comparing operation is effected by comparing each pixel and its surrounding pixels of the inspected pattern unit with the corresponding pixel and its surrounding pixels of the reference pattern unit according to predetermined thresholds to indicate the location of any detected defects.

16. The method according to Claim 11, wherein said converter is an optic charge-coupled device.

17. A method of inspecting the surface of an article for defects, comprising the following operations:

generating a first flow of N streams of data representing the pixels of different images of the inspected article;

generating a second flow of N streams of data representing the pixels of corresponding images of a reference;

and comparing the data of said first flow with the data of the second flow to provide an indication by said comparison of the suspected locations of the inspected article having a high probability of a defect.

18. The method according to Claim 17, wherein said comparing operation is effected by:

correcting any misalignment between the two flows of data;

comparing the data of each stream of the first flow with the data of the corresponding stream of the second flow to provide an alarm value indicating the significance of the presence of a suspected location in the stream;

and detecting a defect at a pixel location according to N alarm values corresponding to the N streams of data.

19. The method according to Claim 18, wherein said correcting any misalignment is effected by:

selecting corresponding registration points in the streams of each flow;

detecting misalignment between the registration points of the two flows;

and shifting one flow with respect to the other flow to correct for said misalignment between the two flows.

20. The method according to Claim 19, wherein said detecting misalignment is effected by computing similarities between corresponding streams of data by summing correlation measures in all possible alignments.

21. The method according to Claim 18, wherein said comparing operation includes:

assigning a type to each pixel in each of the N streams of each flow;

comparing each pixel in each stream of one flow with the corresponding pixel in the corresponding stream of the other flow with respect to predetermined thresholds which depend on the type assigned to the respective pixel;

and assigning an alarm value to the pair of pixels in each comparison in each stream indicating the probability of a defect in the location of the inspected pattern unit corresponding to the respective pixels.

22. The method according to Claim 18, wherein said comparison is further effected by detecting a defect at a pixel location according to the combination of the N alarm values corresponding to the N streams of data.

23. The method according to Claim 21, wherein each pixel is assigned one of a plurality of types according to predetermined parameters with respect to the pixel and its pixel neighbours.

24. The method according to Claim 23, wherein said predetermined parameters include:

(a) local maxima, indicating whether the pixel is a maximum relative to its neighbours;

(b) intensity, indicating whether the intensity of the pixel is significant relative to a predetermined threshold;

(c) ratio of intensity, indicating whether the intensity of the pixel is significant with respect to its neighbours relative to its predetermined threshold; and

(d) gradient, indicating whether the pixel is located in a sloped area with neighbouring pixels relative to a predetermined threshold.

25. The method according to Claim 23, wherein each pixel is assigned any one of a plurality of types including the following:

(a) isolated peak, if the pixel is a local maxima with significant intensity and ratio;

(b) multipeak, if the pixel is not an isolated peak and has significant intensity, and none of its neighbours is an isolated peak;

(c) slope, if either one of the pixel's neighbours is an isolated peak or has significant gradient; and

(d) background, if the pixel has no significant intensity or gradient, and none of its neighbours is an isolated peak.

26. The method according to Claim 17, wherein said N streams of data in each flow are generated by a circular array of N light collectors.

27. The method according to Claim 26, wherein said comparable pattern units are based on a grid of angularly-spaced lines, and said circular array of light collectors include light collectors located to collect the light in regions midway between the angularly-spaced lines of the grid, thereby minimizing the amount of pattern-reflected light collected by the respective light collector.

28. The method according to Claim 26, wherein said grid is constituted of eight 45° spaced lines, there being eight light collectors and eight streams of data in each of said first and second flows.

29. The method according to Claim 17, wherein said generating operations are effected by a laser beam which is deflected to scan a line along one orthogonal axis, while the article to be inspected is physically displaced along a second orthogonal axis.

30. The method according to Claim 17, wherein said article to be inspected has a plurality of comparable pattern units, one of which units serves as an inspected pattern and is compared with at least one other unit of said article serving as a reference pattern.

31. The method according to Claim 30, wherein the article to be inspected is a semiconductor wafer having a plurality of like integrated-circuit dies each formed with like patterns, the pattern of one die serving as the inspected pattern and is compared with the like pattern of at least one other die serving as the reference pattern.

32. The method according to Claim 30, wherein the article to be inspected is a semiconductor wafer having a plurality of like integrated-circuit dies, each die being formed with a plurality of like patterns, one of which patterns of one die serves as the inspected pattern and is compared with another like pattern of the same die serving as the reference pattern.

33. A method of inspecting the surface of an article for defects, comprising the following operations:

imaging, on a converter, each location of the article to be inspected and the corresponding location of a reference article at a plurality of different depths, to output two sets of electric signals for each depth corresponding to the pixels of the inspected article and reference article at that depth;

shifting the electric signals of one set with respect to the electric signals of the other set to match the respective depths of the images;

and comparing the pixels of the inspected article with the corresponding pixels of the reference article to indicate a defect where a mismatch of a predetermined magnitude is found to exist at the respective location of the inspected article.

34. The method according to Claim 33, wherein said imaging at a plurality of different depths is effected by moving the inspected article and reference article towards and away from the converter.

35. The method according to Claim 33, wherein during said imaging at a plurality of different depths, a lamp is flashed at periodic intervals while the inspected article and reference article are being moved with respect to the opto-electric converter.

36. The method according to Claim 33, wherein said comparing operation is effected by comparing each pixel and its surrounding pixels of the inspected article with the corresponding pixel and its surrounding pixels of the reference article according to predetermined thresholds to indicate the location of any detected defects.

37. The method according to Claim 33, wherein said converter is an optic charge-coupled device.

38. The method according to Claim 33, wherein said article to be inspected has a plurality of comparable pattern units, one of which units serves as the inspected pattern and is compared with at least one other unit of said article serving as the reference pattern.

39. The method according to Claim 38, wherein the article to be inspected is a semiconductor wafer having a plurality of like integrated-circuit dies each formed with like patterns, the pattern of one die serving as the inspected pattern and is compared with the like pattern of at least one other die serving as the reference pattern.

40. The method according to Claim 38, wherein the article to be inspected is a semiconductor wafer having a plurality of like integrated-circuit dies, each die being formed with a plurality of like patterns, one of which patterns of one die serves as the inspected pattern and is compared with another like pattern of the same die serving as the reference pattern.

41. Inspection apparatus for inspecting the surface of articles for defects, comprising:

a table for receiving the article to be inspected;

first examining means overlying said table for examining in a first phase the complete surface of the article thereon at a relatively high speed and with a relatively low spatial resolution, and for outputting information indicating suspected locations on the article surface having a high probability of a defect;

storage means for storing the output of said first examining means;

and second examining means overlying said table for examining, in a second phase and with a relatively high spatial resolution, only said suspected locations stored in said storage means, and for outputting information indicating the presence or absence of a defect in the suspected location.

42. The apparatus according to Claim 41, wherein said first examining means includes optic scanning means for optically scanning the complete article surface to be inspected; and said second examining means includes imaging means for imaging only said suspected locations on a converter which converts the images to electrical signals.

43. The apparatus according to Claim 42, wherein said converter is an optic charge-coupled device.

44. The apparatus according to Claim 41, wherein:

the article to be examined has a plurality of comparable pattern units to be inspected, by comparing each such unit, identified as an inspected pattern unit, with at least one other pattern unit, identified as a reference pattern unit; and

said first examining means includes means for outputting information identifying locations on the inspected pattern unit in which the comparison shows sufficient differences with respect to the reference pattern unit to indicate a high probability of defect in the inspected pattern unit.

45. The apparatus according to Claim 41, wherein said table is constructed to support a semi-conductor wafer having a plurality of like integrated-circuit dies each formed with like patterns, the first and second examining means being located to examine and compare the pattern of one die serving as the inspected pattern unit with a like pattern of at least one other die serving as the reference pattern unit.

46. The apparatus according to Claim 45, wherein said table is constructed to support a semi-conductor wafer having a plurality of integrated-circuit dies, each formed with a plurality of like pattern units, the first and second examining means being located to examine and compare each pattern unit of one die serving as the inspected pattern unit with another like pattern unit of the same die serving as the reference pattern unit.

47. The apparatus according to Claim 41, wherein said first examining means comprises:

means for generating a first flow of N streams of data representing the pixels of different images of the inspected pattern unit, and a second flow of N streams of data representing the pixels of corresponding images of the reference pattern unit;

and a processor for comparing the data of said first flow with the data of the second flow, to provide an indication by said comparison of the suspected locations of the suspected pattern unit having a high probability of a defect.

48. The apparatus according to Claim 47, wherein said processor includes:

misalignment correcting means for correcting any misalignment between the two flows of data:

comparison means for comparing the data of each stream of the first flow with the data of the corresponding stream of the second flow to provide an alarm value indicating the significance of the presence of a suspected pixel in the stream;

and detector means for detecting a defect at a pixel location according to N alarm values corresponding to the N streams of data.

49. The apparatus according to Claim 41, wherein said second examining means comprises:

illumination means for illuminating each suspected location of the inspected article, and a corresponding location on a reference article;

converter means for receiving the images of the illuminated areas of the inspected article and of the reference article, and for converting said images to two sets of electrical signals representing pixels of the received images of the inspected article and of the reference article, respectively;

and comparison means for comparing the two sets of images and for outputting an electrical signal indicating a defect at a location wherein a mismatch of a predetermined magnitude occurs between the inspected article image and the reference article image.

50. The apparatus according to Claim 49, wherein said second examining means further comprises:

depth-varying means for producing a plurality of images on said converter means at different depths at said suspected locations on the inspected article and corresponding locations on the reference article;

and shifting means for shifting the electrical signals of one set with respect to those of the other set to match the respective depths of the two sets of images.

51. The apparatus according to Claim 50, wherein said depth-varying means includes a drive for moving the inspected article and the reference article towards and away from said converter to produce said plurality of images at different depths.

52. The apparatus according to Claim 49, wherein said illuminating means includes a flashlamp which is periodically flashed to permit successive illuminations of the inspected article and the reference article on-the-fly while said articles are in motion.

53. The apparatus according to Claim 49, wherein said comparison means includes a processor which compares the two sets of images pixel-by-pixel, with each pixel including its surrounding pixels, in accordance with predetermined thresholds.

54. The apparatus according to Claim 53, wherein said comparison means outputs signals indicating the location of each defect detected.

55. Apparatus for inspecting articles having a plurality of comparable pattern units to be inspected, by comparing each such unit,

identified as an inspected pattern unit, with at least one other, identified as a reference pattern unit, comprising:

a table for supporting the article to be inspected;

means for generating a first flow of N streams of data representing the pixels of different images of the inspected pattern unit, and a second flow of N streams of data representing the pixels of corresponding images of the reference pattern unit;

and a processor for comparing the data of said first flow with the data of the second flow, to provide an indication by said comparison of the suspected locations of the suspected pattern unit having a high probability of a defect.

56. The apparatus according to Claim 55, wherein said processor includes:

misalignment correcting means for correcting any misalignment between the two flows of data:

comparison means for comparing the data of each stream of the first flow with the data of the corresponding stream of the second flow to provide an alarm value indicating the significance of the presence of a suspected pixel in the stream;

and detector means for detecting a defect at a pixel location according to N alarm values corresponding to the N streams of data.

57. The apparatus according to Claim 56, wherein said misalignment correcting means includes:

misalignment detector means for detecting misalignment between a registration point in at least one stream of each flow;

and shifting means for shifting one flow with respect to the other flow to correct for said misalignment.

58. The apparatus according to Claim 57, wherein said misalignment detector means includes means for computing similarities between corresponding streams of data by summing correlation measurements at selected locations in all possible misalignments.

59. The apparatus according to Claim 58, wherein said means for computing similarities comprises a correlation matrix including a correlation measure for each possible misalignment between the two streams, and said shifting means shifts one stream with respect to the other according to the output of said correlation matrix.

60. The apparatus according to Claim 56, wherein said comparison means includes assigning means for assigning each pixel in each stream of each flow with one of a plurality of types according to predetermined

parameters with respect to it and its pixel neighbours, and means for comparing corresponding pixels in the two streams with respect to predetermined thresholds which depend on the type assigned to the respective pixel in the inspected-article stream of pixels.

61. The apparatus according to Claim 60, wherein said comparison means includes means for detecting a defect at a pixel location according to the combination of the N alarm values corresponding to the N streams of data.

62. The apparatus according to Claim 61, wherein said assigning means assigns each pixel one of a plurality of types according to the following parameters:

(a) local maxima, indicating whether the pixel is a maximum relative to its neighbours;

(b) intensity, indicating whether the intensity of the pixel is significant relative to a predetermined threshold;

(c) ratio of intensity, indicating whether the intensity of the pixel is significant with respect to its neighbours relative to its predetermined threshold; and

(d) gradient, indicating whether the pixel is located in a sloped area with neighbouring pixels relative to a predetermined threshold.

63. The apparatus according to Claim 61, wherein said parameters include the following:

(a) isolated peak, if the pixel is a local maxima with significant intensity and ratio;

(b) multipeak, if the pixel is not an isolated peak and has significant intensity, and none of its neighbours is an isolated peak;

(c) slope, if either one of the pixel's neighbours is an isolated peak or has significant gradient; and

(d) background, if the pixel has no significant intensity or gradient, and none of its neighbours is an isolated peak.

64. The apparatus according to Claim 55, wherein said means for generating said first and second flows of N streams of data comprises:

optic scanning means including a light source outputting a light beam which scans in two dimensions the complete surfaces of the comparable pattern units to be inspected;

and light detector means for detecting the light reflected from said surfaces.

65. The apparatus according to Claim 64, wherein said light detector means comprises a circular array of light collectors.

66. The apparatus according to Claim 65, wherein said comparable pattern units are based on a grid of angularly-spaced lines; and said circular array of light collectors include light collectors located to collect the light in regions midway between the angularly-spaced lines of the grid, thereby minimizing the amount of pattern-reflected light collected by the respective light collector.

67. The apparatus according to Claim 66, wherein there are eight light collectors spaced apart at 45° intervals.

68. The apparatus according to Claim 65, wherein said optic scanning means further includes a light deflector for deflecting the light beam along one orthogonal axis, and means for moving the article along another orthogonal axis to thereby effect the two-dimensional scanning of the comparable pattern units to be inspected.

69. The apparatus according to Claim 65, wherein each of said light collectors includes an optic fibre for guiding the light to the respective light detector.

70. The apparatus according to Claim 69, wherein the light receiving end of each of said optic fibres is of a shaped, curved configuration having sides converging from a base substantially parallel to the inspected article, to a pointed tip overlying the inspected article.

71. The apparatus according to Claim 70, wherein the width of the light receiving end of each of said optic fibres is about 16° at its base and forms an angle of about 49° between its base and its tip.

72. The apparatus according to Claim 64, wherein said light source is a laser.

73. The apparatus according to Claim 72, wherein said laser outputs a linearly polarized beam; and said optic scanning means further includes a polarizer between the laser and the article to be inspected which converts the linearly polarized beam to a circularly polarized beam applied to the surface of the inspected article.

74. The apparatus according to Claim 73, wherein said polarizer also converts the light reflected from the article to linear polarization orthogonal to the linear polarization direction of the polarized laser beam; and wherein said optic scanning means includes a further light detector for receiving the reflected light from said polarizer, and a beam splitter between the laser and polarizer for reflecting the reflected light to the further light detector and for blocking the reflected light from the laser.

75. The apparatus according to Claim 69, wherein said optic scanning means further includes an acousto-optic deflector which deflects the light beam along said one orthogonal axis in a sawtooth pattern in the time domain; and a drive for driving the inspected article along the other orthogonal axis to effect the two-dimensional scanning of the surface of the inspected article.

76. The apparatus according to Claim 68, wherein said optic scanning means further includes a beam expander between the light source and the light deflector, and a cylindrical lens which focusses the expanded beam on the light deflector.

77. The apparatus according to Claim 68, wherein said optic scanning means further includes a multi-magnification telescope having a rotatable turret carrying different objectives for focussing the light beam on the article to be inspected.

78. The apparatus according to Claim 55, wherein said table is constructed to support a semi-conductor wafer having a plurality of like integrated-circuit dies each formed with like patterns, the pattern of one die serving as the inspected pattern unit to be compared with a like pattern of at least one other die serving as the reference pattern unit.

79. The apparatus according to Claim 55, wherein said table is constructed to support a semi-conductor wafer having a plurality of integrated-circuit dies, each formed with a plurality of like pattern units, one pattern unit of one die serving as the inspected pattern unit to be compared with another like pattern unit of the same die serving as the reference pattern unit.

80. Apparatus for inspecting articles having a plurality of comparable pattern units to be inspected, by comparing each such unit, identified as an inspected pattern unit, with at least one other, identified as a reference pattern unit, comprising:

a table for supporting the articles to be inspected;

illuminating means for illuminating a predetermined location of the inspected article, and a corresponding location of the reference article;

converter means for receiving the images of the illuminated areas of the inspected article and of the reference article, and for converting said images to two sets of electrical signals representing pixels of the received images of the inspected article and of the reference article, respectively;

and a processor for comparing the two sets of images and for outputting an electrical signal indicating a defect at a location wherein a mismatch of a predetermined magnitude occurs between the inspected article image and the reference article image.

81. The apparatus according to Claim 80, further comprising:

depth-varying means for producing a plurality of images on said converter means of different depths at said predetermined locations of the inspected article and corresponding locations of the reference article;

and shifting means for shifting the electrical signals of one set with respect to those of the other set to match the respective depths of the two sets of images.

82. The apparatus according to Claim 81, wherein said depth-varying means includes a drive for moving the inspected article and the reference article towards and away from said converter to produce said plurality of images at different depths.

83. The apparatus according to Claim 80, wherein said illuminating means includes a flashlamp which is periodically flashed to permit successive illuminations of the inspected article and the reference article on-the-fly while said articles are in motion.

84. The apparatus according to Claim 80, wherein said processor compares the two sets of images pixel-by-pixel, with each pixel including its surrounding pixels, in accordance with predetermined thresholds.

85. The apparatus according to Claim 84, wherein said processor outputs signals indicating the location of each defect detected.

86. The apparatus according to Claim 80, wherein said table is constructed to support a semi-conductor wafer having a plurality of like integrated-circuit dies each formed with like patterns, the pattern of one die serving as the inspected pattern unit to be compared with a like pattern of at least one other die serving as the reference pattern unit.

87. The apparatus according to Claim 80, wherein said table is constructed to support a semi-conductor wafer having a plurality of integrated-circuit dies, each formed with a plurality of like pattern units, one pattern unit of one die serving as the inspected pattern unit to be compared with another like pattern unit of the same die serving as the reference pattern unit.

88. The method according to Claim 5, wherein said repetitive pattern units are spaced from each other a predetermined distance such as to define repetitive pattern zones, and the suspected locations outputted

from said first phase are restricted to locations in said repetitive pattern zones.

89. The apparatus according to Claim 45, wherein said like patterns in all said dies are spaced from each other a predetermined distance such as to define repetitive pattern zones; and said first examining means includes means for suppressing from the suspected locations outputted from said first phase those locations not in said repetitive pattern zones.

90. The method according to Claim 2, wherein said suspected locations are imaged on said converter by darkfield imaging means.

91. The apparatus according to Claim 42, wherein said imaging means of said second examining means is darkfield imaging means.

92. The method according to Claim 17, wherein said second flow of N streams of data representing the pixels of corresponding images of a reference are generated from real images of another like article.

93. The method according to Claim 17, wherein said second flow of N streams of data representing the pixels of corresponding images of a reference are generated from real images of another like pattern on the same article.

94. The method according to Claim 17, wherein said second flow of N streams of data representing the pixels of corresponding images of a reference are generated from simulated images derived from a database.

95. The method according to Claim 26, wherein said N streams of data in said first stream are generated by a circular array of light collectors, and said end streams of data in said second stream are generated from simulated images derived from a database.

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